ESTIMATING CROP WATER USE WITH SATELLITE IMAGERY IN THE MISSISSIPPI DELTA

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INTRODUCTION

Water level declines in the Mississippi River Alluvial Aquifer (alluvial aquifer) have resulted from heavy use of water from the aquifer by agriculture for row crop irrigation, flooding of rice fields, and maintaining levels in catfish ponds. If aquifer water levels continue to decline, the aquifer may eventually be depleted of economically recoverable water and an incredibly valuable natural resource of the region would be severely damaged. To prevent this loss, the YMD Joint Water Management District (YMD) and Area 4 Soil and Water Conservation Districts have undertaken a project with the technical assistance of the Natural Resource Conservation Service (NRCS) to evaluate the feasibility of developing alternative water supplies of the Delta region.

A computer groundwater flow model of the alluvial aquifer is an important and necessary tool for this regional water use planning process. The U.S. Geological Survey (USGS) has agreed to assist in the planning for the development of alternative water supplies by developing the computer model of the alluvial aquifer in a cooperative project with YMD, NRCS, and the Office of Land and Water Resources (OLWR). One component needed for the development of the model is the best possible spatial and temporal estimates of water withdrawals from the aquifer. In the past, YMD has provided this data using data derived from a relational database management system (Stiles and Pennington 1996). While this provided for adequate estimates to begin the modeling process, the main flaw was an inability to accurately locate crops. This inability to specify crop location introduced a significant error in the spatial element of water use calculations. With the availability of inexpensive satellite imagery and PC platform image processing software, YMD intends to establish more accurate crop type designations to be used in water use estimates.

METHODS

In April 1997, a project layout was created to accomplish the goals for image processing. This layout included:

Obtain hardware and software
Gather training regions and accuracy assessment data
Obtain imagery
Classify imagery into crop types
Vectorize crop classes
Combine with digitized irrigated acreages to assign crop
Calculate water use

After contacting Space Imaging, a satellite imagery provider, several dates through the irrigation season were established for data gathering. Training regions were gathered using several methods (Brophy and Stiles 1997). Each polygon site was visited on the date of data acquisition by the satellite. Point data were gathered randomly throughout the growing season. See Figure 1, Delta Map with Ground Truth Points.

In October of 1997, a Micron Dual 300 MHz PC was purchased. This machine is used for image processing. ERMapper, an image processing application, was purchased in November 1997. It was chosen for its ease of use and compatibility with existing data sets in MapInfo. MapInfo is a Geographic Information System (GIS). Two scenes of LandSat TM data were purchased in February 1998.

For easier processing, a 100,000-acre watershed was selected as the project area. See Figure 2, Delta County Map with Project Watershed in Black. Using ERMapper, the imagery within the watershed was classified into several categories using a Maximum Likelihood Nearest Neighbor classification scheme. These categories included: Cotton, Beans, Fish Culture, Rice, Corn, Bare Soil, and Urban.

Each crop category was vectorized. These vectors were then imported into MapInfo. By combining each crop layer with digitized irrigated boundaries, a crop type was able to be determined. Where an irrigated boundary intersected with more than one crop type, the crop designation with highest capacity for water use was assigned. For example, where an irrigated boundary intersected a bean vector and a rice vector, the irrigated boundary was assigned rice.

In order to calculate water use, a combination of data was extracted from MapInfo and imported into a spreadsheet (EXCEL). These included:

Well Permit Number
Latitude
Longitude
Acreage

Crop Type
Monthly Disbursements of Water
Total

Within EXCEL, a formula was created that used the crop type for each well to determine which constants to use in water use calculation. The annual water use was then dispersed monthly throughout the growing season. See Figure 3, Water Use Data Dispersed by Month. The ability for the user to change constants, resulting in an automatic recalculation of the annual water use for each well, was added to the spreadsheet provided to the USGS. This will allow for yearly "what-if" scenarios to be created quite easily by the user. See Figure 4, Constants Used in Water Use Calculation.

SUMMARY

While this methodology works quite well and provides more accurate crop type designations, there is still work to be done on the classification process. Probably, multi-date scenes will have to be purchased for any given year to obtain appropriate crop types. Additionally, crop calendars may need to be used to determine what stages in plant growth provide the best contrasting signature for classification. As time permits and experience is gained, a cleaner looking classification should be derived.

REFERENCES

Stiles, Mark and Dean Pennington. 1996. Estimates of 1995 water use from the Mississippi River alluvial aquifer for each of 12,000 permitted wells. In Proceedings of the 26th Mississippi Water Resources Conference, April 2-3, 1996, edited by B. Jean Daniel, 18-25. Mississippi State University: Water Resources Research Institute.

Stiles, Mark and Kevin Brophy. 1998. Using GPS in Ground Truthing for Supervised Crop Classification in Mississippi Delta. In Proceedings of the 28th Mississippi Water Resources Conference, April 7-8, 1998, edited by B. Jean Daniel. (In press). Mississippi State University: Water Resources Research Institute.

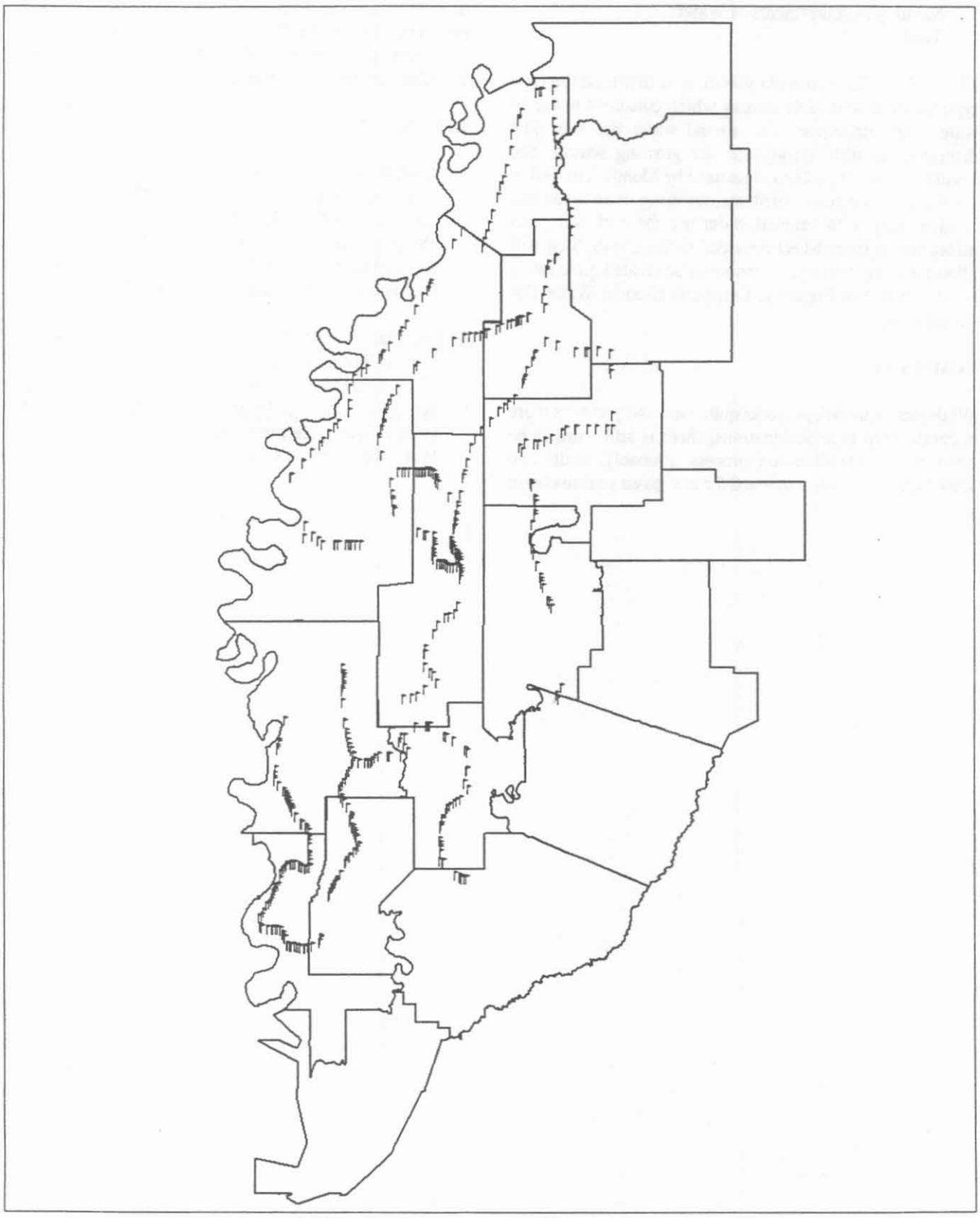

Figure 1. Delta County Map with Ground Truth Points

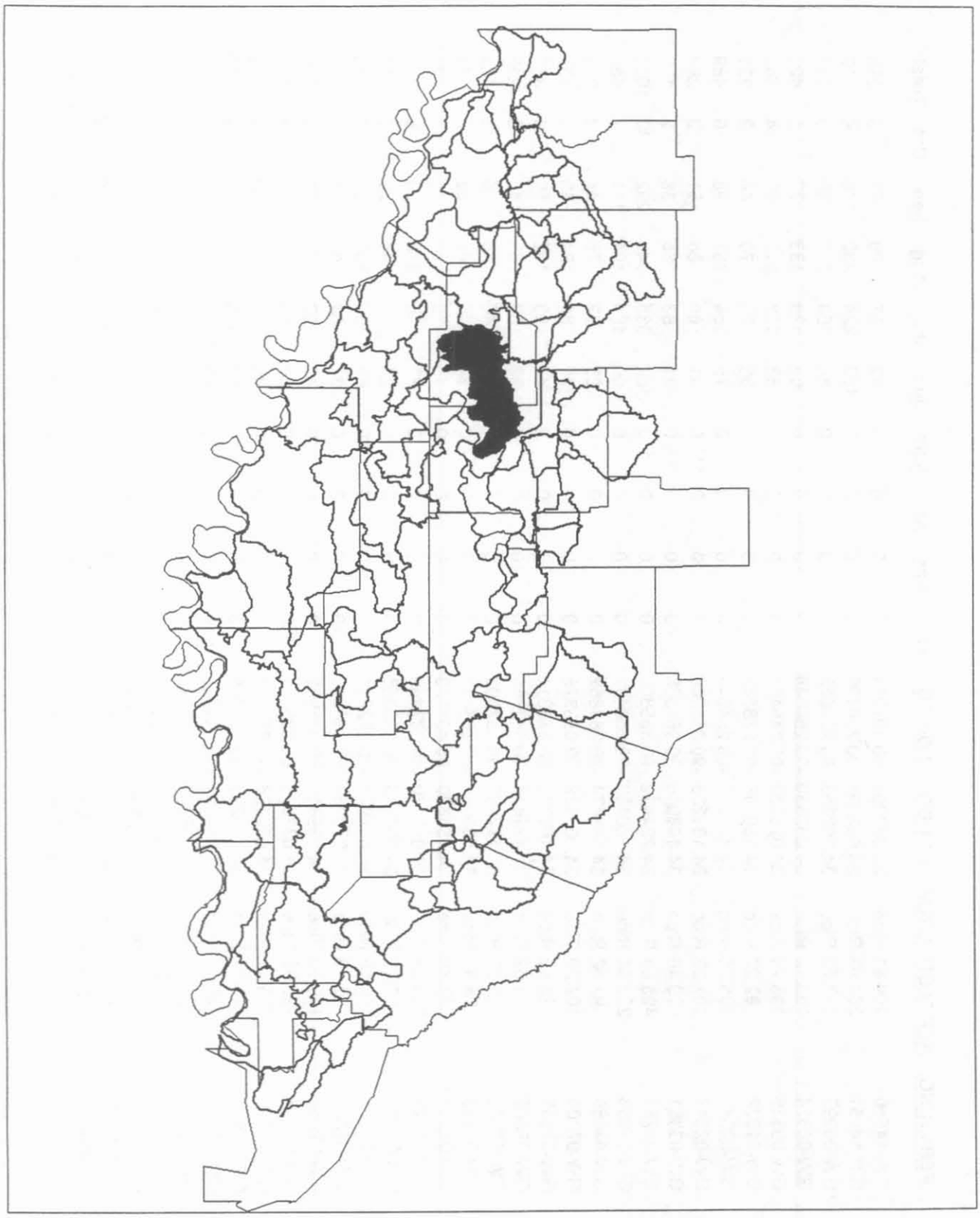

Figure 2. Delta County Map with Project Watershed in Black

PERMIT NO.	ACREAGE	CROP	LAT DD	LON DD	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
GW-14550	109.81	Rice	34.047097	-90.191244	0	0	0	0	42	87	90	52	3	275
GW-14551	283.93	Rice	34.063693	-90.210190	0	0	0	0	109	224	233	135	9	710
GW-00095	207.73	Rice	34.102352	-90.298656	0	0	0	0	80	164	170	99	6	519
GW-00334	162.12	Rice	34.032330	-90.254648	0	0	0	0	62	128	133	77	5	405
GW-00336	136.74	Rice	34.025332	-90.246452	0	0	0	0	53	108	112	65	4	342
GW-01822	92.27	Rice	34.180348	-90.278568	0	0	0	0	36	73	76	44	3	231
GW-02346	195.75	Rice	34.170696	-90.254644	0	0	0	0	75	154	161	93	6	489
GW-02347	107.23	Rice	34.161956	-90.255204	0	0	0	0	41	85	88	51	3	268
GW-03061	79.46	Rice	34.198616	-90.381558	0	0	0	0	31	63	65	38	2	199
GW-03751	425.04	Rice	34.224422	-90.355602	0	0	0	0	164	335	349	202	13	1063
GW-04253	232.91	Rice	34.166166	-90.265432	0	0	0	0	90	184	191	111	7	582
GW-04658	92.52	Rice	34.186474	-90.284852	0	0	0	0	36	73	76	44	3	231
GW-07003	102.29	Rice	34.166188	-90.353376	0	0	0	0	39	81	84	49	3	256
GW-07005	123.89	Rice	34.162270	-90.373314	0	0	0	0	48	98	102	59	4	310
GW-07006	84.62	Rice	34.171494	-90.372360	0	0	0	0	33	67	69	40	3	212
GW-07008	58.23	Rice	34.172406	-90.382908	0	0	0	0	22	46	48	28	2	146
GW-07010	58.33	Rice	34.161666	-90.386498	0	0	0	0	22	46	48	28	2	146
GW-07011	37.79	Rice	34.158690	-90.401130	0	0	0	0	15	30	31	18	1	94
GW-07245	209.83	Rice	34.052770	-90.287440	0	0	0	0	81	166	172	100	6	525
GW-07246	54.21	Rice	34.054758	-90.278356	0	0	0	0	21	43	44	26	2	136
GW-07247	176.15	Rice	34.047926	-90.272024	0	0	0	0	68	139	145	84	5	440
GW-07251	80.79	Rice	34.070930	-90.286048	0	0	0	0	31	64	66	38	2	202
GW-07252	116.30	Rice	34.039810	-90.271982	0	0	0	0	45	92	95	55	4	291
GW-07256	125.98	Rice	34.037870	-90.286034	0	0	0	0	49	99	103	60	4	315
GW-07259	126.17	Rice	34.032426	-90.271912	0	0	0	0	49	100	104	60	4	315
GW-07474	143.81	Rice	34.133238	-90.302018	0	0	0	0	55	113	118	68	4	360
GW-07577	241.48	Rice	33.964482	-90.294990	0	0	0	0	93	191	198	115	7	604
GW-08331	151.20	Rice	34.026046	-90.267782	0	0	0	0	58	119	124	72	5	378
GW-08333	324.74	Rice	34.065450	-90.324908	0	0	0	0	125	256	266	154	10	812
GW-08334	37.94	Rice	34.066296	-90.316038	0	0	0	0	15	30	31	18	1	95
GW-08336	282.72	Rice	34.184074	-90.269232	0	0	0	0	109	223	232	134	9	707
GW-08629	235.44	Rice	34.119264	-90.236812	0	0	0	0	91	186	193	112	7	589
GW-08633	208.63	Rice	34.151806	-90.246174	0	0	0	0	80	165	171	99	6	522

Figure 3. Water Use Data Dispersed by Month

1997 Water Use

	Acre Inches	Acre Ft.	Acre Ft. Winter
Cotton	8	0.67	
Corn	12	1.00	
Rice	30	2.50	
Beans	8	0.67	
Fish Culture	36	1.98	0.99

Adjust the Constants on this screen to input changes into the monthly water use by crop type. These changes will be reflected throughout the entire dataset. EX: If you would like to change the annual water use for Rice, change the appropriate cell in the column titled **Acre Inches**. Acre Feet will be automatically calculated and the rest of the spreadsheet will be updated.

Monthly Coef.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Cotton	0.00	0.00	0.00	0.00	0.1541	0.3156	0.3282	0.1899	0.0122
Corn	0.00	0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.1541	0.3156	0.3282	0.1899	0.0122
Beans	0.00	0.00	0.00	0.00	0.1541	0.3156	0.3282	0.1899	0.0122
Fish Culture	0.25	0.25	0.25	0.25	0.1541	0.3156	0.3282	0.1899	0.0122

Figure 4. Constants Used in Water Use Calculation